Atrial Fibrillation During an Exploration Class Mission

Mark Lipsett MD, PhD
Douglas Hamilton MD, PhD
Jay Lemery MD
James Polk DO

Disclosure Information

82nd Annual Scientific and Human Performance Meeting
Mark Lipsett, Douglas Hamilton, Jay Lemery, James Polk

Have no financial relationships to disclose

The authors will not discuss off-label use and/or investigational use in this presentation

Outline

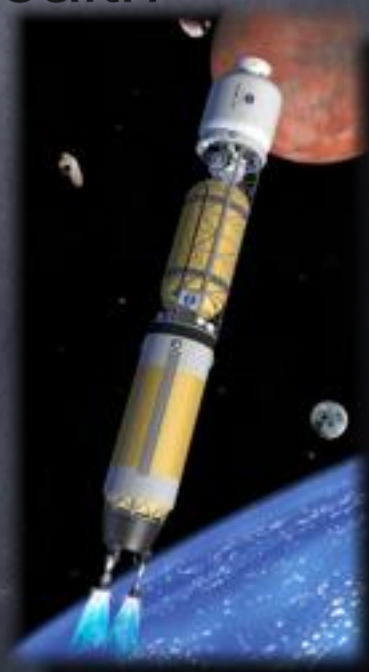
1. Background
2. Causes of Atrial Fibrillation
3. Mission to Mars
4. Medical Resources
5. Distant Medical Management
6. Mission Summary

Outline

1. Background
2. Causes of Atrial Fibrillation
3. Mission to Mars
4. Medical Resources
5. Distant Medical Management
6. Mission Summary

Mission Background

- After a several month journey, the 7-member crew is preparing to enter a low Mars orbit
- You, the **flight surgeon**, have just received the mission commander's video message supplemented with the crew's biometrics & health status
- The message, delayed by the 20 min transmission lag, confirms the "return to duty" criteria for mission specialist (M.C.)



Medical Background

- M.C., a 51-yo mission scientist had presented 2 months earlier via a “store & forward” PMC with the chief complaint of **Cardiac Palpitations**
- M.C. indicated feeling a strange “fluttering” & “pressure” in his chest during these bouts
- Three episodes, lasting ~3hr & terminating with bed rest, were diagnosed as **Paroxysmal Atrial Fibrillation (PAF)**

Medical Background

- M.C.'s cardiac exam 30 days before mission take-off indicated: ø CAD risk factors
  ø cardiac Ca^{2+} score
  ø significant ectopy during Holter

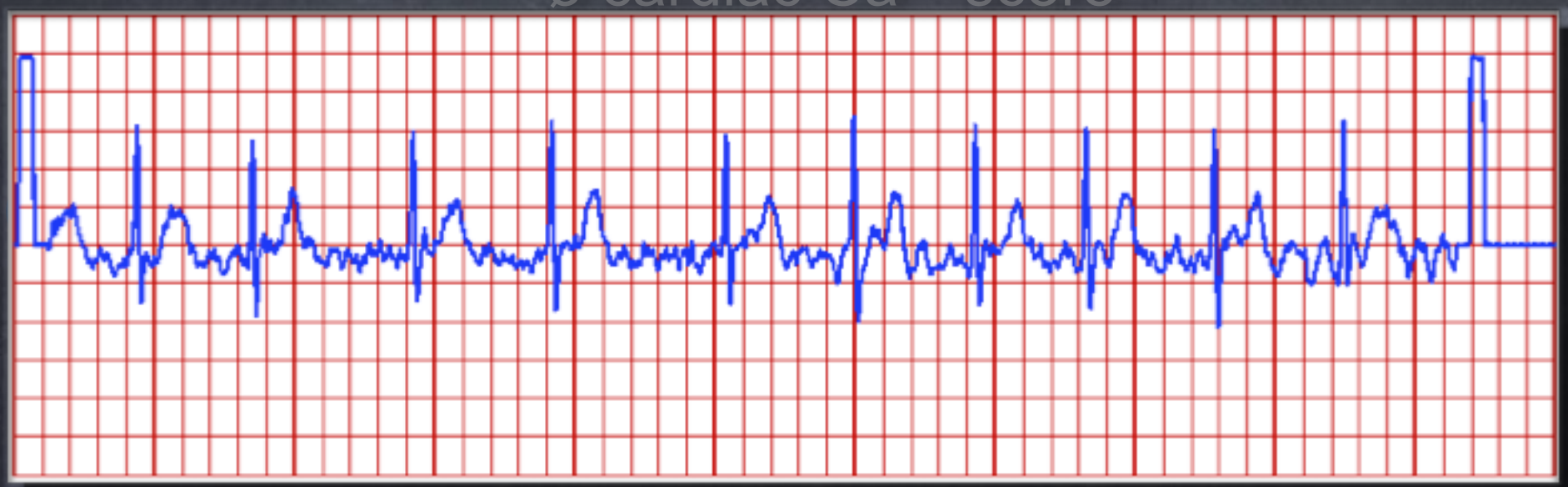
Medical Background

- M.C.'s cardiac exam 30 days before mission take-off indicated: ø CAD risk factors
  ø cardiac Ca^{2+} score
  ø significant ectopy during Holter

- EKG obtained during all three **PAF** episodes revealed
  AF with: ventricular rate of ~150 bpm
  narrow complex QRS
  ø ST- or T-wave abnormalities

Medical Background

- M.C.'s cardiac exam 30 days before mission take-off indicated: ø CAD risk factors
  ø cardiac Ca^{2+} score



Medical Background

- M.C.'s cardiac exam 30 days before mission take-off indicated: ø CAD risk factors
  ø cardiac Ca^{2+} score
  ø significant ectopy during Holter

- EKG obtained during all three **PAF** episodes revealed
  AF with: ventricular rate of ~150 bpm
  narrow complex QRS
  ø ST- or T-wave abnormalities

- M.C. indicated having an URTI 3 weeks before the first bout of PAF in which pseudo-ephedrine was used and a slight hand tremor was noted

Medical Background
AF & the Astronaut Corps

- Since 1950s, 17 cases of **AF** have been diagnosed amongst 317 active & retired astronauts (~**5%**)

Medical Background
AF & the Astronaut Corps

- Since 1950s, 17 cases of **AF** have been diagnosed amongst 317 active & retired astronauts (~**5%**)
- Since 2001, 5 astronauts underwent **RFA** treatment for atrial arrhythmias

Medical Background
AF & the Astronaut Corps

- Since 1950's 17 cases of **AF** have been diagnosed amongst 317 active & retired astronauts (~**5%**)
- Since the 2001, 5 astronauts underwent **RFA** treatment for atrial arrhythmias
- Of significance is the younger age (~40s) in which these arrhythmias are detected (vs >60 years)

Medical Background
AF & the Astronaut Corps

* Since 1950s, 17 cases of **AF** have been diagnosed amongst 317 active & retired astronauts (~**5%**)
* Since 2001, 5 astronauts underwent **RFA** treatment for atrial arrhythmias
* Of significance is the younger age (~40s) in which these arrhythmias are detected (vs >60 years)
* Due to: better health surveillance?
  higher vagal tone?
  random chance?
  gravitational-flux induced?

Outline

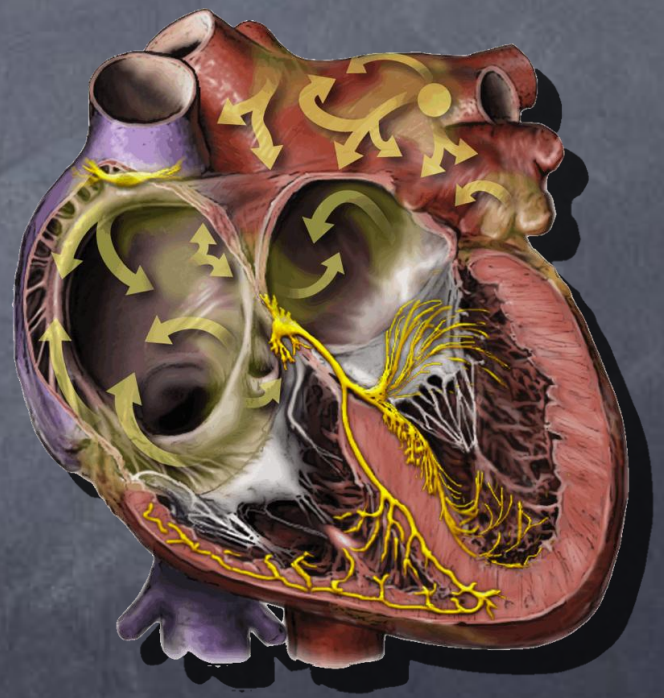
1. Background
2. Causes of Atrial Fibrillation
3. Mission to Mars
4. Medical Resources
5. Distant Medical Management
6. Mission Summary

Outline

1. Background
2. Causes of Atrial Fibrillation
3. Mission to Mars
4. Medical Resources
5. Distant Medical Management
6. Mission Summary

Terrestrial Mechanisms of Atrial Fibrillation

- Structural Heart Disease
- Pericarditis
- Metabolic Disturbances
- Ectopic Beats
- Myocardial Stretch
- Idiopathic



Mission Question 1:
What Caused M.C.'s AF?

a. CO poisoning
b. Cardiomyopathy
c. Iatrogenic
d. Idiopathic AF (lone AF)
e. Myocardial infarction
f. Pericarditis
g. Post-viral thyrotoxicosis
h. Pulmonary embolism
i. Structural

Mission Question 1:
What Caused M.C.'s AF?

a. CO poisoning
b. Cardiomyopathy
c. Iatrogenic
d. Idiopathic AF (lone AF)
e. Myocardial infarction
f. Pericarditis
g. Post-viral thyrotoxicosis
h. Pulmonary embolism
i. Structural

Outline

1. Background
2. Causes of Atrial Fibrillation
3. Mission to Mars
4. Medical Resources
5. Distant Medical Management
6. Mission Summary

Outline

1. Background
2. Causes of Atrial Fibrillation
3. Mission to Mars
4. Medical Resources
5. Distant Medical Management
6. Mission Summary

Continuation of Mission

* The space vehicle is preparing to fire it's engines to enter a parking orbit around Mars

* Any chance of returning to Earth in less than 1 year is impossible

Mission Question 2:
At this point you decide to...

3

a. continue mission, watchful waiting, **EKG** when symptomatic

b. Abort mission due to poor prognosis & risk of **thromboembolic event**

c. continue mission, start **ASA** daily with bi-monthly **EKG** follow-up exams

d. continue mission, start a **β-blocker** for possible thyrotoxic disease

Mission Question 2:
At this point you decide to...

3

a. continue mission, watchful waiting, **EKG** when symptomatic

b. Abort mission due to poor prognosis & risk of **thromboembolic event**

c. continue mission, start **ASA** daily with bi-monthly **EKG** follow-up exams

d. continue mission, start a **β-blocker** for possible thyrotoxic disease

Outline

1. Background
2. Causes of Atrial Fibrillation
3. Mission to Mars
4. Medical Resources
5. Distant Medical Management
6. Mission Summary

Outline

1. Background
2. Causes of Atrial Fibrillation
3. Mission to Mars
4. Medical Resources
5. Distant Medical Management
6. Mission Summary

The Mission at Home

* The last few weeks have been a harrowing experience for you as the mission Flight Surgeon

The Mission at Home

* The last few weeks have been a harrowing experience for you as the mission flight surgeon
* You have organized an international aerospace cardiology expert panel to decide:

The Mission at Home

* The last few weeks have been a harrowing experience for you as the mission Flight Surgeon

* You have organized an international aerospace cardiology expert panel to decide:

  • abort mission, sling-shot burn around Mars and return to Earth within 6 months

The Mission at Home

* The last few weeks have been a harrowing experience for you as the mission Flight Surgeon

* You have organized an international aerospace cardiology expert panel to decide:

  • abort mission, sling-shot burn around Mars and return to Earth within 6 months

  • continuing with the Mars landing and subsequent 1-year surface endeavour

The Mission at Home
Crew Supplies

- Adequate ASA for the whole mission

The Mission at Home
Crew Supplies

- Adequate ASA for the whole mission
- Insufficient anti-coagulation, rate control & rhythm control medications for one astronaut

The Mission at Home
Crew Supplies

* Adequate ASA for the whole mission
* Insufficient anti-coagulation, rate-control & rhythm control medications for one astronaut
* An Automatic External Defibrillator (AED) device

Mission Question 3:
Inquest

In your testimony to the international experts' conference, you state that:

a. ASA is just as effective as warfarin for anti-coagulation

b. the risks and difficulty monitoring warfarin therapy outweigh the stroke risk reduction

c. low-molecular weight heparin is not effective in treating thromboembolic risks associated with AF

d. Immediate electrical cardioversion would preclude the need for anticoagulation

The Mission at Home
Inquest

- At the experts' panel, you present an extensive pre-mission risk/benefit study analysis:
  - long-duration mission profile
  - age and excellent health of crew
  - risk of lone AF and subsequent crew member impact, including fatal stroke
- Conclusions:
  impact & risk of warfarin therapy > ASA therapy
- At time of mission planning, newer direct thrombin inhibitors not yet vetted

Mission Question 3:
Inquest

In your testimony to the international experts' conference, you state that:

a. ASA is just as effective as warfarin for anti-coagulation

b. the risks and difficulty monitoring warfarin therapy outweigh the stroke risk reduction

c. low-molecular weight heparin is not effective in treating thromboembolic risks associated with AF

d. Immediate electrical cardioversion would preclude the need for anticoagulation

Mission Question 3:
Inquest

In your testimony to the international experts' conference, you state that:

a. ASA is just as effective as warfarin for anti-coagulation

b. the risks and difficulty monitoring warfarin therapy outweigh the stroke risk reduction

c. low-molecular weight heparin is not effective in treating thromboembolic risks associated with AF

d. Immediate electrical cardioversion would preclude the need for anticoagulation

Outline

1. Background
2. Causes of Atrial Fibrillation
3. Mission to Mars
4. Medical Resources
5. Distant Medical Management
6. Mission Summary

Outline

1. Background
2. Causes of Atrial Fibrillation
3. Mission to Mars
4. Medical Resources
5. Distant Medical Management
6. Mission Summary

Continuation of Mission

* Their Mars surface mission proceeded uneventfully until ~1 year after landing when M.C. noticed 24 hours of persistent palpitations, just 3 days before scheduled lift-off & return

Continuation of Mission

* Their Mars surface mission proceeded uneventfully until ~1 year after landing when M.C. noticed 24 hours of persistent palpitations, just 3 days before scheduled lift-off & return

* Holter confirmed: **AF** - rapid ventricular response
  165 bpm
  pressure **90/50** mmHg

Continuation of Mission

* Their Mars surface mission proceeded uneventfully until ~1 year after landing when M.C. noticed 24 hours of persistent palpitations, just 3 days before scheduled lift-off & return

* Holter confirmed: **AF** - rapid ventricular response
  165 bpm
  pressure **90/50** mmHg

* M.C. notes feeling uncomfortable, but denies chest pressure or dyspnea

Mission Question 4:

5

At this point, you would recommend:

a **Nothing**, M.C. can be expected to spontaneously convert to NSR in the next 24 hours

b **Rate control** and reassess

c **Rate control** and initiate immediate **chemical cardioversion**

d Immediate **electrical** cardioversion due to **hypotension**

Mission Question 4:

5

At this point, you would recommend:

a **Nothing**, M.C. can be expected to spontaneously convert to NSR in the next 24 hours

b **Rate control** and reassess

c **Rate control** and initiate immediate **chemical cardioversion**

d Immediate **electrical** cardioversion due to **hypotension**

Mission Question 4:

- Rate control first choice, AF can ↓ ventricular filling by ~**20%**

Mission Question 4:

- Rate control first choice, AF can ↓ ventricular filling by ~**20%**
- Ca^{2+} channel blocker vs β-blocker, side-effects

Mission Question 4:

- Rate control first choice, AF can ↓ ventricular filling by ~**20%**
- Ca^{2+} channel blocker vs β-blocker, side-effects
- Spontaneous conversion common <24 hours (~**67%**)

Mission Question 4:

- Rate control first choice, AF can ↓ ventricular filling by ~**20%**
- Ca^{2+} channel blocker vs β-blocker, side-effects
- Spontaneous conversion common <24 hours (~**67%**)
- Electrical cardioversion only when symptomatic

Outline

1. Background
2. Causes of Atrial Fibrillation
3. Mission to Mars
4. Medical Resources
5. Distant Medical Management
6. Mission Summary

Outline

1. Background
2. Causes of Atrial Fibrillation
3. Mission to Mars
4. Medical Resources
5. Distant Medical Management
6. Mission Summary

Continuation of Mission

- Crew member M.C. continued to take ASA and was acutely rate controlled with Ca^{2+} CB

Continuation of Mission

* Crew member M.C. continued to take ASA and was acutely rate controlled with Ca^{2+} CB

* Of interest was his conversion back to NSR during the 4 minutes of $3G_x$ loading during lift off from the Martian surface

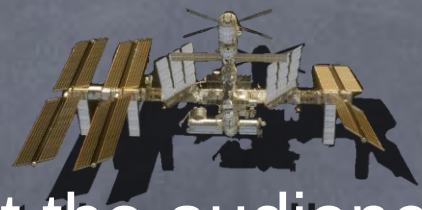
Continuation of Mission

* Crew member M.C. continued to take ASA and was acutely rate controlled with Ca^{2+} CB
* Of interest was his conversion back to NSR during the 4 minutes of $3G_x$ loading during lift off from the Martian surface
* M.C. remained in NSR for the duration of the journey back to Earth and the mission was completed successfully

Summary

- This case was to acquaint the audience with the tremendous challenges that face the flight surgeon and medical team when supporting a space mission

Summary



* This case was to acquaint the audience with the tremendous challenges that face the FS and medical team when supporting a space mission

* Limited crew training time, medical hardware & pharmaceuticals manifested dictate aggressive 1° & 2° prevention strategies to protect a multi-billion dollar asset like the ISS or a mission to the Moon or Mars

Acknowledgements

- Dept. Anaesthesia Memorial University
- Wyle Life Sciences
- NASA - JSC
- CSA
- Jillian Pashley